Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	GN Docket No. 14-177
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	WT Docket No. 10-112

COMMENTS OF QUALCOMM INCORPORATED

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Qualcomm supports the FCC's *Third Further Notice of Proposed Rulemaking* seeking to authorize commercial wireless operations in several additional much-needed millimeter wave bands.[1] Pressure on existing licensed mobile and unlicensed spectrum bands will continue to intensify due to the growing consumer demand for wireless connectivity, and the bands identified in the *FNPRM* will certainly serve an important role in providing 5G and future generations of wireless services. Qualcomm respectfully requests that the FCC authorize mobile and fixed operations in these bands using licensed and shared unlicensed regulatory paradigms, as explained in these comments. By taking these steps, the Commission will ensure critical spectrum assets are used to further U.S. leadership in the development and deployment of 5G and future generation technologies.

[1] *See* Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, *Third Report and Order, Memorandum Opinion and Order, and Third Further Notice of Proposed Rulemaking*, FCC 18-73, GN Docket No. 14-177 (June 8, 2018) ("*FNPRM*").

INTRODUCTION & SUMMARY

Qualcomm supports the FCC's proposals in the *FNPRM* recognizing that the explosive growth in wireless communications services necessitates making available for flexible use additional millimeter wave spectrum, particularly the lower 37 GHz band, the 26 GHz band, and the 42 GHz band.[2] Qualcomm requests that the FCC adopt flexible use rules in these bands so both fixed and mobile deployments can support the delivery of ultra-high-speed mobile broadband connectivity, and ultra-low latency, ultra-reliable services enabled by 5G New Radio ("5G NR") technology.

Specifically with regard to the lower 37 GHz band, Qualcomm requests that the FCC adopt technology-neutral spectrum sharing rules described herein so that new 5G NR-Unlicensed/Shared Spectrum ("5G NR-U/SS") technology can be deployed to provide greatly enhanced broadband connectivity for all users. 5G NR-U/SS offers a level of wireless connectivity that cannot be delivered today in any shared or unlicensed spectrum band using any existing technology. This new technology will deliver a far better user experience for everyone and without adversely affecting anyone.

To enable this new 5G-based technology and other technologies that use compatible sharing techniques in the lower 37 GHz band, the FCC should implement simple, technology-neutral, time synchronization rules to govern co-primary access by new Federal and non-Federal systems so disparate systems can use the same piece of spectrum in the same geographic area at the same time and support applications with a given Quality of Service ("QoS"). Such rules would not mandate 5G NR-U/SS or any other technology, but rather would enable all technologies to coexist successfully and to use the shared spectrum for everyone's benefit. The

[2] *See, e.g., FNPRM* at ¶¶ 47-91.

new 5G NR-U/SS technology, in particular, takes advantage of the extremely fast 5G new radio, the multiple antennas and advanced techniques to enable 5G to transmit in a highly directional manner, using very narrow beams, so multiple co-located users can use the shared spectrum simultaneously — a feat not possible today.

Qualcomm has shown via live demos how 5G NR-U/SS can provide multi-gigabit connectivity to multiple users in the same area using new spectrum sharing techniques such as spatial division multiplexing ("SDM") and coordinated multipoint sharing ("CoMP") and the lower 37 GHz shared spectrum band is a perfect home for these advanced tools.

As Qualcomm has maintained since its founding more than three decades ago, it is critically important for the U.S. government to keep a steady stream of spectrum flowing for commercial purposes to maintain American leadership in 5G and future wireless service generations. Thus, we support opening of the lower 37 GHz band, the 26 GHz band, and the 42 GHz band for flexible use. Aside from modernizing deployment policies to advance wireless infrastructure deployment, the allocation of additional wireless spectrum is critically important to America's economic future. New low-band, mid-band, and high-band spectrum allocations will be key to the successful roll-out of 5G and future wireless service generations.

The additional millimeter wave bands in the *FNPRM* can support IoT operations ranging from precision manufacturing and connected cars to sensors, smart watches, and security cameras. Qualcomm recently announced that our IoT technology solutions reach more than 9,000 manufacturer and solution provider customers, helping them design and commercialize such innovative IoT solutions.[3] Established service providers as well as new entrants are building

[3] *See* Qualcomm Press Release, "Qualcomm Helps to Accelerate IoT Ecosystem Growth Through Breakthrough Innovation and Expanded Channel," (Aug. 2, 2018) *available at* https://www.qualcomm.com/news/releases/2018/08/02/qualcomm-helps-accelerate-iot-

next generation networks to support IoT applications and ultra-high-speed connectivity will vastly improve consumer and business productivity.

Commission support for these use cases, as well as uses we cannot envision today, will help to propel American technological leadership well into the 21st century. The FCC has done outstanding work thus far to open additional spectrum for 5G services, and, as the *FNRPM* makes clear, more work remains. As the leading 5G wireless technology developer, Qualcomm encourages the FCC to move forward in this proceeding along the lines described below.

DISCUSSION

I. As The Leading Developer Of 5G RF Modem Chipset Solutions, Qualcomm Welcomes The FCC's Upcoming Millimeter Wave Band Auctions And Its *Third FNPRM* Proposals To Open Additional Millimeter Wave Bands

Qualcomm is the wireless industry leader in developing 5G New Radio ("5G NR") based RF modems for wireless devices in general and for millimeter wave devices in particular. As Qualcomm leads the U.S. and the rest of the world to 5G, we believe that this next major leap in cellular technology will spur a new era of intelligent, connected devices, supporting connected cars, remote delivery of health care services, and smart cities, smart homes, and personal wearables, all being designed to improve our well-being.

We applaud the FCC's actions over the past several years in this docket to open the millimeter wave bands for mobile use. And we are thrilled by the opportunities presented in the *FNPRM* for spectrum sharing solutions, as discussed below. Moreover, the Commission's efforts to ensure the U.S. is 5G-ready, including scheduling the upcoming auctions of the 28 GHz band (Auction 101) and the 24 GHz band (Auction 102), and the Chairman's announcement that

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ecosystem-growth-through-breakthrough *last accessed* Sept. 10, 2018. Qualcomm Technologies makes available more than 30 production-ready reference design platforms, and we expect this market segment to provide in excess of $1 billion in revenues to Qualcomm in fiscal year 2018.

additional millimeter-wave spectrum bands, *i.e.*, the upper 37 GHz band, 39 GHz band, and the 47 GHz band, will be auctioned during the second half of 2019, are particularly timely.

A. Qualcomm's RF Chipsets Are Powering Initial 5G Deployments And Trials Around The Globe

Qualcomm leads the mobile industry with its 5G New Radio (5G NR") mobile chipsets that operate in the millimeter wave bands, and, based on this leadership, our company is best positioned to develop RF capabilities for the millimeter wave bands identified in the *FNPRM*.[4] Less than two months ago, we unveiled the world's first fully-integrated 5G NR millimeter wave and sub-6 GHz RF modules that deliver modem-to-antenna capabilities across several spectrum bands in a very compact footprint that is suited for integration in smartphones and other mobile devices.[5] Qualcomm's state-of-the-art antenna modules work in tandem with our Snapdragon X50 5G modem to address the formidable challenges associated with operations using the millimeter wave bands by implementing advanced beam forming, beam steering, and beam tracking technologies to improve the range and reliability of millimeter wave communications.

Our 5G chipsets deliver improved mobile broadband connectivity with fiber-like speeds and operate in licensed bands, unlicensed bands, and shared spectrum bands. Just last week, we announced the successful completion of a 3GPP Release 15 specification compliant 5G NR data

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[4] *See* Qualcomm Press Release, "Qualcomm Delivers Breakthrough 5G NR mmWave and Sub-6 GHz RF Modules for Mobile Devices — New family of mmWave antenna modules makes mobile mmWave viable in a smartphone form factor, supporting large-scale commercialization," (July 23, 2018) *available at* https://www.qualcomm.com/news/releases/2018/07/23/qualcomm-delivers-breakthrough-5g-nr-mmwave-and-sub-6-ghz-rf-modules-mobile *last accessed* Sept. 10, 2018.

[5] *See id.*; *and see* Qualcomm Press Release, "Global OEMs Select Qualcomm Snapdragon X50 5G NR Modem Family for Mobile Device Launches in 2019 — Qualcomm and Mobile Device OEMs Focus on Delivering Next-Generation 5G Mobile Experiences with Low Latency, Extreme Capacity and Fiber-Like Connectivity to the Cloud," (Feb. 8, 2018) *available at* https://www.qualcomm.com/news/releases/2018/02/08/global-oems-select-qualcomm-snapdragon-x50-5g-nr-modem-family-mobile-device *last accessed* Sept. 10, 2018.

call on a smartphone form factor mobile test device using the 39 GHz band in Non-Standalone mode.[6] We are very excited by the potential uses offered by the 26 GHz, the lower 37 GHz, and 42 GHz bands teed up in the *FNPRM*, especially by the possibility of deploying 5G New Radio for Unlicensed and Shared Spectrum ("5G NR-U/SS) in the lower 37 GHz shared band.

RF operations in these new millimeter wave bands would use the advanced technologies Qualcomm has developed to support the millimeter wave bands the FCC has already allocated. As explained above, Qualcomm's latest 5G RF modules show that the small wavelengths at these millimeter wave frequencies allow for miniaturized antennas, a collection of which can be packed into a very small area and be intelligently controlled. These antennas use adaptive beamforming to dynamically find the most efficient signal path direction between the transmitter and receiver, which includes non-line-of-sight paths that reflect off of walls and buildings, and travel around corners and down corridors and alleys. And, where an active millimeter wave connection cannot be maintained, the RF modem automatically switches to a different band to maintain connectivity.[7]

B. Millimeter Wave Band Operations Go Hand-in-Hand with Increased Network Densification

In conjunction with the advent of Licensed Assisted Access ("LAA") delivering Gigabit LTE, the deployment of 5G NR millimeter-wave technology now under way is shifting the cellular network infrastructure paradigm from a network comprised mainly of macro-cells to a

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[6] *See* Qualcomm Press Release, "Qualcomm and Ericsson Conduct First Announced 3GPP-compliant 5G NR mmWave OTA Call with a Mobile Form Factor Device — Demonstration Marks Next Critical Milestone for 5G Development; Continues Path to Commercialization of Mobile Handsets in the First Half of 2019," (Sept. 6, 2018) *available at* https://www.qualcomm.com/news/releases/2018/09/06/qualcomm-and-ericsson-conduct-first-announced-3gpp-compliant-5g-nr-mmwave *last accessed* Sept. 10, 2018.

[7] *See* Qualcomm Snapdragon X50 5G Modem Infographic," *available at* https://www.qualcomm.com/products/snapdragon/modems/5g/x50, *last accessed* Sept. 10, 2018.

network that also includes highly densified collections of small cells that support highly-reliable, ultra-high-speed, multi-band operations. This shift to increased network densification not only is necessary to support increasing demands for ultra-high speed, ultra-reliable mobile broadband connectivity but also to support 5G millimeter wave technology which uses wide swaths of spectrum to deliver multi-gigabit, low latency connectivity and operates with shorter signal paths than what is supported by a traditional macro-cellular network.

Facilitating network densification via small cell deployments, today with LAA and very soon with 5G, will enable efficient broadband delivery using both millimeter wave spectrum bands and lower spectrum bands, be they licensed, unlicensed, or shared bands.[8] Small cells can be strategically placed in very close proximity to where additional coverage/performance is needed and be readily integrated into the macro-cellular networks.[9] Thus, the FCC's ongoing efforts to streamline approval procedures for small cell deployments are critically important to the success of 5G.

II. The Lower 37 GHz Band Can Use 5G NR-U/SS To Support Multiple Users Operating On The Same Swath Of Spectrum At The Same Time And In The Same Geographic Area

Qualcomm and our wireless industry partners are actively developing novel spectrum access techniques that provide even greater spectrum utilization among multiple users in the same geographic area and on the same piece of spectrum. These new spectrum sharing techniques will enable all users to enjoy much faster, better mobile broadband than anyone can

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8 *See, e.g.,* Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment, *Second Report and Order*, WT Docket No. 17-79, FCC 18-30 (Mar. 30, 2018).

9 *See* Dean Brenner, Qualcomm OnQ Blog, "FCC acts to accelerate small cell deployments & 5G readiness," (Apr. 12, 2018) *available at* https://www.qualcomm.com/news/onq/2018/04/12/fcc-takes-action-accelerate-small-cell-deployments-and-strengthen-5g-readiness, *last accessed* Sept. 10, 2018.

currently receive in any shared spectrum band using any existing technology. We have demonstrated how advanced access and transmission techniques enable much improved overall network performance that can support a sustained Quality of Service ("QoS") to multiple users in the same area and on the same piece of spectrum during extremely high loading conditions.[10] At Mobile World Congress 2018, in March, for example, we showcased a live demonstration of the benefits of 5G NR-U/SS showing two operators providing well more than 1 Gbps connectivity in the same geographic area over the same 100 MHz swath of mid-band spectrum.[11]

These 5G NR-U/SS techniques are being standardized by 3GPP. The 3GPP standardization efforts, which began last year at an industry-wide workshop Qualcomm hosted in San Diego, are targeting greenfield shared and unlicensed spectrum to support the development of highly advanced spectrum sharing paradigms that deliver significant benefits in terms of increased spectral efficiency, superior throughput, and improved QoS.

As explained below, Qualcomm recommends that the FCC enable 5G NR-U/SS in the lower 37 GHz band by implementing a simple set of technology neutral rules that provide fair spectrum sharing among multiple co-located users. These rules would not just enable 5G NR-U/SS. They would enable any and all technologies that use compatible spectrum sharing techniques. For its part, with such rules in place, 5G NR-U/SS can provide a coordination

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[10] *See* Yongbin Wei, Qualcomm OnQ Blog, "What can we do with 5G NR Spectrum Sharing that isn't possible today?" (Jan. 3, 2018) *available at* https://www.qualcomm.com/news/onq/2018/01/03/what-can-we-do-5g-nr-spectrum-sharing-isnt-possible-today, *last accessed* Sept. 10, 2018.

[11] A video of the "5G NR Spectrum Sharing (March 1, 2018)" demonstration is accessible on Qualcomm's 5G Spectrum Sharing website *available at* https://www.qualcomm.com/invention/technologies/5g-nr/spectrum-sharing *last accessed* Sept. 10, 2018.

mechanism through which co-primary Federal and non-Federal users can access the lower 37 GHz band, as set out in prior Commission Orders in this docket.[12]

A. 5G NR-U/SS Uses Revolutionary Sharing Techniques To Provide Much Improved User Experiences And A Given Quality of Service ("QoS")

5G NR-U/SS can enable wireless system operators, including those with limited or no licensed spectrum, to offer fiber-like 5G experiences within new shared or unlicensed bands.[13] 5G NR-U/SS can support multiple operators in the same physical area operating on the same channel and at the same time, vastly improving overall spectral efficiency and utilization.

Use of multiple antennas is becoming increasingly common in wireless systems that operate in the millimeter wave frequency bands. These multi-antenna systems allow transmission links to become highly directional, and this directionality can be exploited to significantly improve spectrum reuse and greatly increase overall system capacity. For instance, spatial division multiplexing ("SDM") and coordinated multipoint sharing ("CoMP") techniques allow for the creation and steering of highly focused beams to specified directions. These techniques enable multiple radio links to simultaneously communicate on the same channel and in the same geographical area, not only for the radio nodes of a single operator but also for radio nodes of multiple operators that overlap in space, time, and frequency. Advanced sharing techniques like time-division multiplexing also enable guaranteed spectrum access for services that require a given QoS, vastly increasing spectral efficiency and value.

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12 *See FNPRM* at ¶¶ 59-60.

13 *See, e.g.*, Dean Brenner, Qualcomm OnQ Blog, "Wireless innovation — From LTE-U/LAA to 5G spectrum sharing," (Mar. 29, 2018) *available at* https://www.qualcomm.com/news/onq/2018/03/29/lte-u-5g-spectrum-sharing *last accessed* Sept. 10, 2018.

B. A Simple Database Coupled With A Technology Neutral Medium Access Protocol Can Enable 5G NR-U/SS and Other Technologies In The Lower 37 GHz Band

The lower 37 GHz band presents an excellent opportunity for the deployment of 5G NR-U/SS technology. Protection of existing Federal operations in the lower 37 GHz band can be provided via a database, as the FCC notes.[14] Prior to being allowed access to the band, new commercial or Federal users can check the database to ensure they do not cause harmful interference to existing users, such as the Space Research Service ("SRS") in the entire lower 37 GHz band and Fixed Satellite Service ("FSS") in the 37.5 to 37.6 GHz portion of the lower 37 GHz band. 5G NR-U/SS is being designed to support such database access to enable 5G operations in both unlicensed or shared spectrum bands.[15]

For new Federal and non-Federal (*e.g.*, commercial) entrants to the lower 37 GHz band, Qualcomm recommends using an over-the-air coordination procedure that will enable vastly improved spectrum utilization. Millimeter wave band operations enable a higher degree of spatial multiplexing through the use of narrow beams, as explained above. For these high band operations, silencing of nearby nodes is needed only to protect receivers and not transmitters. Therefore, the use of a location-based database is inefficient, since location-based silencing typically does not account for beam directionality and locations of all mobile receivers. In order to ensure adequate protection, location-based silencing would necessarily be overly conservative, and thus curtail spectral efficiency.

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14 *See FNPRM* at ¶¶ 62-68.

15 In addition, it may be desirable for new Federal users in the band — deployed in areas where commercial users are located — to transmit a signature waveform that can be detected by commercial users to enable operations within an exclusion zone possibly without accessing any database.

Over-the-air mechanisms can improve spectrum utilization, but it is important to address the fact that detection of the receiver is, in practice, harder to accomplish than the detection of the transmitter. For operations in lower frequency bands, *e.g.*, sub-6 GHz, there is high degree of correlation between the transmitter and receiver protection because of the propagation characteristics. In the lower bands, energy-based sensing and an explicit protection of the transmitter has been successfully implemented. However, this strategy is not particularly effective in the high frequency bands where path loss is much greater and substantial transmitter and receiver antenna gains are used to meet link budgets. The resulting narrow beam millimeter wave communications systems characteristics results in significantly less correlation between the detection of the transmitter and the protection of the receiver.

To address this technical reality, Qualcomm recommends implementing a simple set of technology-neutral rules, which can be supported by 5G NR-U/SS and other technologies, in the lower 37 GHz band to improved spectrum sharing among Federal and non-Federal (*e.g.*, commercial) operations. For example, a medium reservation mechanism that combines the use of a technology-neutral waveform and energy-based sensing can reserve the medium only in the space utilized for the communications link and only for the time when such communications occur. For the lower 37 GHz band, Qualcomm recommends using a medium access principle that protects the receiver. This can be best accomplished by having the receiver transmit a signal indicating active reception that nearby transmitters can detect.

This sharing approach uses medium reservation windows in time, which are based on an absolute system time. The medium reservation window system allows a user to reserve the medium until the beginning of the next medium reservation window. This enables effective control of hidden node and exposed node interference and supports improved QoS since all

potential transmitters can detect nearby receivers that gain the medium first. Access slots within the medium reservation window can be used at random, be deterministic, or there can be a hybrid where slot assignment is random within a part of the medium reservation widow.

Medium access outside the synchronized medium reservation window is allowed, but only if the node monitors the slots in the last synchronized medium reservation window and medium use is not detected. In this case, the medium use must end before the start of the subsequent synchronized access slot. The alignment of the medium reservation window only is required if the presence of a node performing medium access based on absolute system time is detected through over the air signaling utilizing a predefined signature waveform within a certain period of time. This allows a system that does not follow the technology neutral rules to operate in this spectrum.

However, once a node performing medium access based on absolute system time is detected, it also has to perform in accordance with those rules or defer to those operations that do. Simple, technology neutral rules that implement this approach would provide greatly spectrum utilization in areas with high levels of activity, as Qualcomm has shown as explained above.

C. The Proposed Medium Reservation Window Approach Can Support Multiple Overlapping Licensees In The Same Area And On The Same Channels

The technology-neutral medium reservation window approach described above would allow multiple licensees to operate in the same geographic area, on the same channel, and at the same time. Thus, this approach can support multiple overlapping site cluster licenses and base station licenses,[16] allowing each operator to provide broad area coverage, share in the increased

16 *See FNPRM* at ¶¶ 71-72.

spectral efficiency, and provide a sustained throughput and reliable QoS. While 5G NR-U/SS can support this functionality, it is possible for other technologies to follow this set of technology neutral rules and provide much improved levels of spectrum utilization.

Depending on the particular Federal operations in the lower 37 GHz band, 5G NR-U/SS offers a means of enabling equal or priority access by those users. In the case of equal access, for example, Federal users would use the same access procedure as non-Federal users. Higher priority access may be achieved through database access or over the air signaling. The database could be used to protect new Federal users in the same fashion as it is used to protect existing Federal users. However, as noted above, over the air mechanisms offer greater flexibility and improved performance for new Federal users as well. New Federal users could experience these same benefits were it also to follow these technology neutral rules, that is, periodically transmit a predefined waveform that all users, Federal and non-Federal would be required to detect, and if detected, follow the procedure discussed above.

Qualcomm respectfully requests that the FCC implement this technology-neutral approach in the lower 37 GHz band.

III. Qualcomm Supports Opening The 26 GHz and 42 GHz Bands For Licensed Flexible Use

A. The Commission Should Adopt Operating Rules For The 26 GHz Band Consistent With The Rules That Apply To The 24 and 28 GHz Bands

Qualcomm supports the FCC's proposal to authorize use of the 25.25-27.5 GHz ("26 GHz") band for flexible fixed and mobile services on an exclusive licensed basis, and we believe that geographic area licensing should be done on a Partial Economic Area ("PEA") basis.[17] The 26 GHz band has been a primary 5G focus of other countries and, because of this,

[17] *See FNPRM* at ¶ 89.

the band is likely to be globally harmonized and support manufacturing economies of scale and international roaming.[18]

The Commission should rely upon the successful Part 30 regulatory framework that applies to other millimeter wave bands instead of looking to untested, experimental licensing approaches.[19] Indeed, opening the 26 GHz band would provide a nearly contiguous 4 GHz-wide block of spectrum for 5G services when considered with the already allocated 24 GHz and 28 GHz bands.

Also, the FCC should not permit use of the 26 GHz band for High Altitude Platform Systems ("HAPS") unaffiliated with terrestrial fixed and mobile licensees because this could lead to interference with terrestrial fixed and mobile systems operating under Part 30 regulations.[20]

B. The FCC Also Should Apply The Part 30 Rules To The 42 GHz Band

Qualcomm supports licensing the 42-42.5 GHz ("42 GHz") band on an exclusive basis utilizing PEA geographic licenses, which the FCC also has used in the 37 GHz, 39 GHz, and 47 GHz bands, as this will encourage the rapid buildout of new and innovative 5G services in the band. As with the 26 GHz band discussed above, Qualcomm agrees with the Commission that it should apply the Part 30 regulatory framework to this band.[21]

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18 *See FNPRM* at ¶¶ 76-78.

19 *See id.*

20 *See FNPRM* at ¶¶ 86-87.

21 *See FNPRM* at ¶ 52.

CONCLUSION

Qualcomm encourages the FCC to open the lower 37 GHz, the 26 GHz, and the 42 GHz bands for mobile and fixed services along the lines described above. 5G networks will require additional licensed and shared spectrum to support the growing demands for enhanced mobile broadband, massive IoT, and mission critical services, and the bands identified in the *FNPRM* are needed to support these demands. Qualcomm is extremely excited by the possibilities offered by the millimeter wave bands because we believe they will serve a critical role in providing ultra-reliable, ultra-low-latency, multi-gigabit per second applications and services to American consumers and businesses.

Respectfully submitted,

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